the Mechelecív

Volume 24 November - 1965 No. 2

THE GEORGE WASHINGTON UNIVERSITY

NOVEMBER 1965

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THE PLAYBOY ENGINEER. . . AGAIN

In the months of March and April of last spring, Mecheleciv Magazine introduced a thoughtful young man called the Playboy Engineer. The purpose of this introduction was threefold: firstly, to attempt to knock a few holes in the image of the engineer as a drudge, secondly, to stimulate some thought directed toward doing rather than viewing and thirdly, to attempt to expose the writers philosophy of life to the slings and arrows of outrageous readers.

It was hoped that P.E. would spark enough interest in said readers by his stimulating, interesting, soul searching disclosure of his unique philosophy that they would dash off thoughtful answers by return mail. This action would in turn have a threefold reaction; firstly, it would relieve the frustrations of said mythical readers, secondly, it would support or modify the writers own philosophy and thirdly, it would provide a source of future editorials for the unimaginative editor.

Below is the second of the two letters prompted by the editorials. The first, printed in the May issue, took issue with the Playboy Engineer's attitude. This one, happily enough, supports the original philosophy.

"Dear Sir:

After reading the Playboy Engineer's Philosophy in the March and April issues of Mecheleciv, I can find few points for argument. I only wish that more people would learn to distinguish between the rich ne'r-do-well and the true 'playboy'. I agree wholeheartedly with the philosophy of 'working and playing with all one's might'.

Sometimes, it seems that too much emphasis is placed on the virtue of hard work. True, to earn the privilege of playing hard, one must first work hard, but hard work is not an end in itself. It is a means to an end, achievement of a goal, such as wealth or happiness.

I greatly admire a 'self-made' man. He has truly earned his success. However, if, in his scramble for success he didn't find time to play or enjoy the process of living, he missed something vital. The French have a term for it which is translated into something like 'the joy of life'.

The true Playboy, (Engineer or otherwise) knows how and when to draw the line between horsing around at a T.G.I.F. party and running an efficient office or writing a term paper. If the Playboy Engineer gives his full attention to both work and play, he has a good chance of achieving a healthy, happy and balanced life.

Yours Sincerely,
Celeste L. Remley
Washington, D. C.

The interesting thing to note is that the first letter was written by a graduate engineer in the wilds of Ohio with a deep interest in the profession, and the second was written by a rather attractive young lady with a deep interest in enjoying life. Out of all the undergraduates, graduates and faculty members of the School of Engineering, Mecheleciv didn't even get a post card or a nasty memo about the Playboy Engineer.

One reason could be that the articles were not stimulating, interesting or soul searching. Another could be that because of the readers inherent inertia, they were not stimulated or interested enough to search their souls or think, a trying past-time at best. If inertia is the reason, this editor has got to try to give the old First Law a shove.

Now is the time of his life that the student engineer should be formulating some sort of philosophy to guide his life. Life is short and the only way a man can make the most efficient use of the allotted time and fully enjoy it is to determine his goals and develop an attitude toward his work and play. Mr. Doug Lowe's article, "The Stream of Life" in this issue, says what I am trying to say in a more readable manner.

My message this month, boys and girls, is . . . get interested! Write letters to the editors, join professional societies, have parties, become a great engineer rather than a fair one, raise hell and put a block under it . . . but what ever you do, work or play, do it "with all thy might".

Now is the time. One of the easiest things to become is an I-wish-I-had. It's harder but much more satisfying to be an I'm-glad-I-did.

the Mecheleciv

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ARTICLES

DEPARTMENTS

COVER

This month's cover, done by author Jerry Edwards, symbolizes the advances made in precise Measurement Science as evidenced by two of our articles. The only measurement standard not represented is the distance between the first and second joint of a working engineer's middle finger, known as the "practical inch."

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MOTOROLA

THE TRANSDUCER A

Mr. Jerry L. Edwards is a full time graduate student working in the Metralogy program under an N.S.F. Engineering Traineeship. Jerry was editor last year and was in his undergraduate years, Regent of Theta Tau and Chairman of A.S.M.E. as well as a commissioned 2nd Lt. in the U.S.A.F. from the R.O.T.C. program.

by Jerry L. Edwards

The "art" of measurement has always been very much a part of engineering. Measurements are necessary both to test engineering theory and to provide information when the theory cannot. But in spite of its importance, this subject of measurement has never been given much emphasis in engineering education. For, until recently, it has always been possible for the engineer to pick up enough measurement "know-how" to get along, without ever studying the subject in much detail. Common sense and large "safety factors" have sufficed.

Modern science and industry, however, are now demanding so much in the way of precise, dependable measurements that there is a rapidly expanding need for engineers who have studied the subject in considerable detail. Furthermore, measurements of high accuracy are usually very expensive, and so there is a great demand for the engineer who can substitute knowledge for money. For reasons such as these, The Center For Measurement Science was established at this University in 1960 with the full encouragement and support of the space industry, the instrument manufacturing industry, along with several government agencies including the National Bureau of Standards.

This paper was written to provide an introduction to this subject called "metrology" or measurement science and to present a brief, but quite general theory of the measurement transducer.

THE MEASUREMENT PROCESS

A measurement is usually carried by the use of some kind of instrument to determine the magnitude of some property of interest. This magnitude is expressed by the use of a unit of a convenient size and a numerical multiplier. The size of every unit is determined by and maintained by the use of actual physical standards. For example, the size of the kilogram unit is fixed by one particular mass of platinum-iridium metal kept in a vault at Sevres, France. A standard need not always be some material object. For example, the presently accepted standard for length units is the wavelength of a particular frequency of light emitted by the element Krypton.

In 1960 a system of units designated by "SI" in all languages was accepted by 36 nations including the United States. In that system, all other units are defined in terms of the following six units:

LENGTH	meter (m)
MASS	kilogram (kg)
TIME	second (s)
ELECTRIC CURRENT	ampere (A)
TEMPERATURE	degree Kelvin (^{o}K)
LUMINOUS INTENSITY	candela (cd)

For each of these units and for each of the derived units there is a corresponding physical standard.

The important point is that no matter what the unit used, there exists some tangible physical standard to back it up. Because of this, every measurement must at some stage involve a comparison between the unknown quantity being measured and a standard (or known quantity of what is being measured). So the accuracy of a measurement depends on the accuracy of the standard and on the accuracy of the comparison.

DIRECT AND INDIRECT COMPARISONS

To emphasize the above points, it is useful to classify measurements into two types:

(1) Direct Comparisons, and

(2) Indirect Comparisons.

Of these, the indirect comparisons are the most common. For them the comparison with standards takes place "automatically"; it occurred in a process commonly called a calibration. The use of a direct reading voltmeter is an example of an indirect-comparison measurement. The use of a mercury thermometer is another.

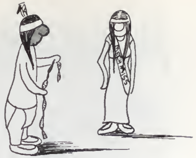
Measurements by direct comparison, except in special cases such as length measurements with a ruler, is usually restricted to precise measurements and calibrations. The student of metrology learns very quickly that all of the very best measurements at the National Bureau of Standards are made by direct comparison methods. For example, the most precise measurements of voltage involve direct comparison with standard Weston cells. Almost all precise mass measurements are made using a double pan balance which is, of course, a direct comparison between known and unknown masses.

GENERALIZED TRANSDUCER THEORY

Rather than going into detail on particular kinds of measurements in a short paper such as this, it is felt that a brief, but general discussion of transducers would be more useful because of their common use in nearly all measurements, both direct and indirect comparisons. The treatment that follows is based mainly on a paper by Peter K. Stein of the Arizona State University (reference 1). Much of his terminology and many of his definitions, however, have been modified for reasons of clarification.

The measurement transducer can be thought of as a device for increasing the range and sensitivity of man's own senses and for obtaining quantitative information about the world. But the transducer, in general, is defined as any device which converts energy from one form into another. Examples of measurement transducers include

EASUREMENT SCIENCE



the Geiger counter which converts nuclear energy into electrical energy, the microphone which converts acoustic energy into electrical, and the galvanometer which converts electrical energy into mechanical.

In the analysis that follows we will use the "Black Box" technique in which we ignore the insides of the transducer. Then the transducer can be represented as shown in figure 1.

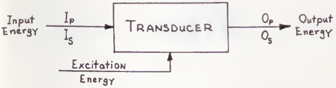


Figure 1

When the transducer requires no external or excitation energy for its operation, it is called a self-generating transducer. The thermocouple, the Bourdon-tube pressure gage, and the galvanometer are all self-generating transducers.

When the transducer does require an excitation energy, it is called a passive or non-self-generating transducer. All transducers which operate by means of resistance, inductance, or capacitance changes are included in this class. In the energy conversion approach used here, passive and self-generating transducers can be treated in the same way if the excitation energy is combined with the output energy. In which case the resultant output energy can be thought of as a form of "modulated" excitation energy.

PRIMARY AND SECONDARY QUANTITIES

In most applications, it is some quantity such as force, temperature, or electric current which is to be measured rather than energy. However, if such quantities are called primary quantities, (or the "measurands"), then it is always possible to find a corresponding secondary quantity such that their product is energy (or power). Let

- I_p be the primary input quantity, (which is to be measured)
- I_s be the secondary output quantity,
- O_p be the primary output quantity, and
- O_s be the secondary output quantity,

then I_pI_s is the input energy, and
O_pO_s is the output energy.

Now, we can treat any two of the four quantities above as dependent variables and the remaining two as independent variables. In measurement applications, we usually want O_p as a dependent variable and I_p as an independent variable. Thus, we write the following functional relationships:

$$O_p = O_p\,(I_p\ ,\ O_s) \qquad (1)$$

$$I_s = I_s\,(I_p\ ,\ O_s) \qquad (2)$$

Taking the total differentials of O_p and I_s, we have

$$dO_p = T_p\,dI_p + E\,dO_s \qquad (3)$$

$$dI_s = A^{-1}\,dI_p + T_s^{-1}\,dO_s \qquad (4)$$

where $T_p = \left(\frac{\partial O_p}{\partial I_p}\right)_{O_s}$ and is called the "primary sensitivity", (5)

$T_s = \left(\frac{\partial O_s}{\partial I_s}\right)_{I_p}$ and is called the "secondary sensitivity", (6)

$E = \left(\frac{\partial O_p}{\partial O_s}\right)_{I_p}$ and is called the "emittance", (7)

$A = \left(\frac{\partial I_p}{\partial I_s}\right)_{O_s}$ and is called the "acceptance". (8)

The integrated form of equation (5), $O_p = f\,(I_p)$, is called the transfer function for the transducer. The "emittance" and "acceptance" are closely related to the concepts of output and input impedance used in electrical engineering network theory. In fact, when O_p and I_p are voltages and O_s and I_s are currents, they are identical.

Professor Stein does not define the transducer parameters in the above manner. As a result, the parameter T_s is missing in his treatment. The approach used here is similar to that used by Louis de Pian and Robert Moore of this University in their treatment of electromechanical transducers. (See reference 2.)

REQUIREMENTS FOR GOOD MEASUREMENT TRANSDUCERS

A transducer to be used in measurement applications should have the following characteristics:

(1) The transducer should have a high (primary) sensitivity.
(2) The primary output should be a highly reproducible function of the primary input which is to be measured.
(3) The transducer should be reasonably linear; that is, T_p, T_s, E, and A should be nearly constant.
(4) The transducer should have low emittance and high acceptance.

—Continued on page 22

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DEVELOPMENT OF AN
SCIENCE CURRICULU

The following article is the text from a speech delivered by Dean Grisamore on Oct. 5, 1965 before a National meeting of the Instrument Society of America in Los Angeles, California.

Three years ago this month a report was made at the annual ISA Conference in New York on the new educational program in Measurement Science offered by The George Washington University. At that time we were enthused over the prospect of offering a much needed academic program and over the interest shown by some portions of industry and the government in this project. There is a certain amount of detailed history on the founding of this project which I will not go into, since it was reported in the annual conference previously mentioned. Any person who's curiosity compels him to know this history can see me after this session.

EXPERIENCE

We now have an additional three years experience in our program and while our enthusiasm has not diminished, it has pointed itself in a somewhat different direction. Our experience has shown that the main tangible support for an academic program in measurement science comes from the manufacturers of precision equipment and only slightly if at all from the users. For example, we have approximately $100,000 worth of precision equipment which has been donated, with one exception, by instrument manufacturers; we have two scholarships, other than NASA and NSF fellowships, specifically for metrology, both given by instrument manufacturers; and we have a number of graduate students supported in their studies through tuition aid but they all are government employees of various calibration and standards laboratories. Before you assume that there is no interest in measurement science education by organizations other than those mentioned I need to relate some additional experience.

A number of times each year we offer the short, one week, type of course in a number of different subjects related to measurement science ranging from microwave measurements to maintainability. These courses do not carry credit in an academic degree program but are designed more for the person already engaged in metrology who wishes to increase or up-date his knowledge in a specific area. (Two one week programs will be offered in January 1966; one on Maintainability, and one on the Operation of Standards and Calibration Laboratories.) These programs have been well attended by persons from all segments of industry and government. In summation then, it can be stated that the segment of industry associated with instrument manufacture is interested in supporting sophisticated, fundamental academic programs in metrology, whereas the "users" are more concerned with training programs of immediate use to their employees. Upon reflection it is not the least bit surprising that this state of affairs exists. Instrument manufacturers are the group who obviously have a greater knowledge and appreciation of the depth of education needed to solve instrumentation problems, whereas the other segments of industry treat standards and calibrations activities as a support function; a sort of necessary evil that they hope in time will disappear. This latter group is quite correctly concerned mainly with the immediate technology of measurement science. Personally, I think they don't put quite enough emphasis on metrology but on the other hand, if I didn't feel this way, I wouldn't be here now.

ENROLLMENT

Now, let's take a look at the present academic enrollment in the Measurement Science Courses. As of this moment there are 75 students enrolled in these courses. Before you begin to exclaim with joy over this situation let's break this figure down to meaningful terms. Twenty-four of these students are in the graduate program, 5 of the 24 being in the Doctor of Science program, the remainder in the Master's program. Of the 51 undergraduate students, 12 are students who are not in any degree program. These students are probably taking these courses because it will directly aid them in their employment. The remaining 39 undergraduate students are in various engineering curricula since we require all students to have some background in measurement science. All 75 students mentioned are enrolled in one or more of eight different metrology courses; it is quite probable that there are a number of students working on theses who are not included in this group. I have no exact figures for this group but I suspect it is fewer than ten.

CONCLUSIONS

If one includes the information given above with that obtained in previous years, a number of different conclusions can be drawn concerning the student body. First, the great preponderance of students in the metrology curriculum are at the graduate level. They are mainly engineers and physicists who have been employed in jobs directly concerned with measurement science; e.g., each year we receive two to four applications for the graduate program from persons employed in government standards and calibration laboratories. Second, courses in measurement sciences are becoming more "popular"

EXPERIENCE WITH A MEASUREMENT
AT THE COLLEGE LEVEL


NELSON T. GRISAMORE
Ass't Dean (Research) and Director, Center for Measurement Science

with engineering and science majors at the undergraduate level indicating that students realize the importance of this topic in their general educational background. Third, there appears to be a need for courses in measurement science on a continuing or adult education basis. Fourth, there is either a lack of interest or a lack of knowledge of employment opportunities by entering freshmen or other undergraduate students. It is quite possible that it may be best to limit the degree curricula to the graduate level and have only supporting courses at the undergraduate level.

The principal effort in the research field has been the thesis work of the graduate students. During the period 1962 to the present, fifteen Master's Theses have been accepted. Other research activities have been carried on in medical measurements and instrumentation and in general Transducer Theory. In addition, we have conducted a training program for NASA quality assurance personnel to educate them in the general aspects of metrology and correct practices in the organization and operation of standards and calibration laboratories.

I would like to close this paper with a comment made by the Dean of our School, Martin A. Mason, at a recent ASQC meeting.

"Spectacular progress has been made by instrument manufacturers in making available better, more accurate instruments. Unfortunately, there is little evidence that most users have either developed the machinery or the measurement personnel competent to exploit the advances available."

Titles of Theses Submitted for Degree of Master of Science in Engineering in Metrology

1. Improvements in a Time-of-Flight Mass Spectrometer, Robert Morton Mills. February 1964.
2. A Study of the Factors Affecting the Precision of Length Measurement with Interference Comparators, Mohamed Fadl Ahmed Fadl. February 1964.
3. The Investigation of the Feasibility of Using Dynamic Wave Forms as Generated by Piezoelectric Crystals as Standards for Surface Roughness, Jay Leon Chamberlin. June 1964.
4. A Study of Experimental and Data Evaluation Techniques in Bomb Calorimetry and their Contributions to the Scatter of Measurements, Arnold Alpert. June 1964.
5. Frequency Stabilization of the Helium-Neon Laser, Kitt Earl Gillilland. June 1964.
6. A Thermal Wattmeter Capable of High Accuracy to 10,000 Cycles Per Second, William Ambrose Hagan. June 1964.
7. The Feasibility of Employing the Hall Effect Phenomena in a Transfer Wattmeter, Joseph Caesar Santo. June 1964.
8. A Precision Voltage Ratio Set, Woodward G. Eicke. February 1965.
9. A Semiconductor Square Law Device for Precise Electrical Measurements, Kenneth Putkovich. February 1965.
10. Liquid Surface Interferometry for Determining Optical Planeness of Surfaces, Anthony D. Skufa. February 1965.
11. Measurement of Vibrations of the Chest Wall due to the Activity of the Heart, Alan S. Berson. June 1965.
12. Principles and Errors in Roundness Measurements, Richard J. Francis. June 1965.
13. Investigation of the Sensitivity of Electromagnetic Flow Transducers Used for Measuring Ship's Speed, L. W. Griswold. February 1962.
14. Conformal Mapping Function to Convert the Electro-magnetic Flowmeter Equation to the Electro-magnetic Rodmeter, C.K. Fang. June 1962.
15. Incidental Frequency Modulation in Klystron Oscillators Operated Under 100% Amplitude Modulated Conditions, C. Weil-Malherbe. June 1963.

STREAM OF LIFE

by Douglas W. Lowe

Doug Lowe's paper was the local winner in the Tau Beta Pi pledge essay contest last spring and went on to win the National pledge essay contest taking a $100 award. Doug is active in Theta Tau, Tau Beta Pi, Sigma Tau and is on the crew team. He is majoring in Structural Engineering and plans to continue in graduate work after graduation in Feb. 1966.

For just a moment, let us step from the rapid-flowing stream of life onto its shaded banks where we may pause to consider its content, its form, and its direction. High in the mountains, water seeps from the ground, gathers in rivulets, trickles into creeks and streams, joins with the mighty rivers, and finally flows into the vastness of the oceans.

Initially it is sparklingly pure and clear, very slow-moving, very beautiful to behold. As it flows in increasing quantity, its movement is quickened, its course decided more rapidly. It bubbles and splashes around boulders and over rocks with a singing voice, bursting with the joy of freedom and anticipating the unknown everywhere ahead.

Then, almost imperceptibly at first, the mood of the stream changes. No longer does its course lie in the undisturbed seclusion of the forest. Open holes begin to appear in the leafy archway high over head. Sunlight begins to strike the stream as it widens. No longer does it dash wildly to and fro, seeking another place, another level. It flows more smoothly, more slowly. Sunlight no longer reaches the bottom: it is trapped in the clouds of silt which have appeared along with waters from fields not protected by the mantle of the forest. Its voice is subdued as it quietly passes on, disturbing nothing around it. The stream is changing.

Occasionally, it will regain its bubbly speed and joyfully sparkle again, but these times are rare. In the ceaseless meanderings of the stream, the course is usually selected by the principle of least action. Changes are accepted as natural and necessary parts of forward motion; the concepts of reversing the flow to go upstream and lose the silt clouds, to go back to the beauty that existed in the forest are lost and unthinkable.

Soon this stream will merge with others to form the muddy waters of rivers. Its strength will be increased many-fold, but the price of this strength is the cost of the freedom of direction. Stagnation in backwaters or tidal ponds is the fate of those river elements which leave the current to find their own way. The entrance of the stream into the rivers signals the loss of stream identity and the end of the struggle to maintain that identity. There is nothing left but the inevitable course to the sea, where the progress and efforts of incoming streams can be quietly observed and predicted.

Do we have to yield to the inevitability of our destination? Should we let ourselves be so preoccupied with the immediate task of finding a path around each obstacle, each rock in real life, that we lose sight of the goals we strive for and lose control over the means to achieve those goals?

In this very fast-paced and complex society of which we are a part, it has become the custom to hurry: to hurry through childhood and the teen years in order to get a faster start on life, to hurry through college in order to begin work sooner, to hurry through work in order to get ahead--but ahead to what? We are trying to get farther downstream at a faster rate than anyone else, to jump out into the lead because we have grown accustomed to the idea that such is the proper behavior. The fact that such behavior seems normal does not mean that it should be accepted.

The ancient Greeks believed that the good life is the exercise of one's vital powers toward the accomplishment of great ends. It is the use of the innate and the acquired abilities to their fullest extent with the knowledge that anything worthy of human effort can be in itself a great end. However, we are failing to achieve the most from the good life because for too many years we wander along, taking things as they come to us and learning only what is taught to us, trusting all the while that as we drift with the mainstream our course will take us to some desired but nebulous place in the future.

This is a very risky way to proceed. Fortunately, with the proper will and determination, we as men can pause to take stock of ourselves and our surroundings. Certainly, there is safety in accepting things as they are, unquestioningly, because the mainstream will still continue to flow forward and carry us with it. However, we will never achieve the full life and be able to contribute to it until we begin to be more selective in our thinking and begin to consider the value of going upstream, begin to appreciate the clear and sparkling waters which we have before hurrying ever onward only to encounter the wistfully clouded waters of disappointment and discontent at a point farther downstream. Perhaps, we should consider the words of Thoreau in Walden:

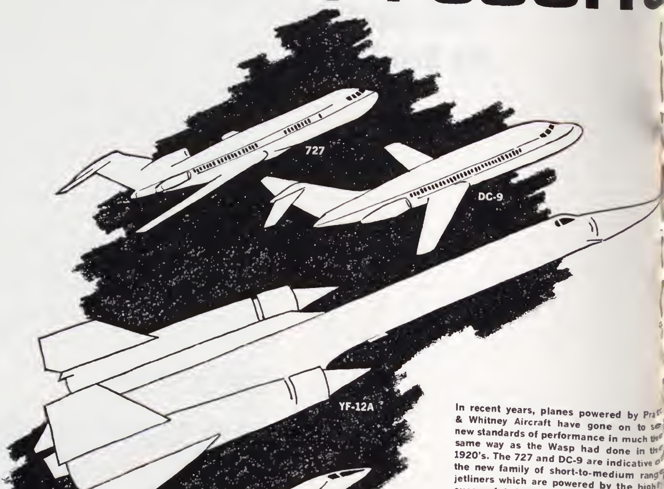
> Why should we be in such a desperate haste to succeed? If a man does not keep pace with his companions, perhaps it is because he hears a different drummer. Let him step to the music which he hears, however measured or far away.

Each of us should try to find his own drummer. There are so many different and exciting things in this life, in this world, that we would never run out of new, interesting, and challenging ones, unless, of course, we pass by too many in our hurry to get ahead, in our rush to get farther downstream.

Past

The Company's first engine, the Wasp, to the air on May 5, 1926. Within a year Wasp set its first world record and went to smash existing records and set standa for both land and seaplanes for years come, carrying airframes and pilots hig farther, and faster than they had ever before.

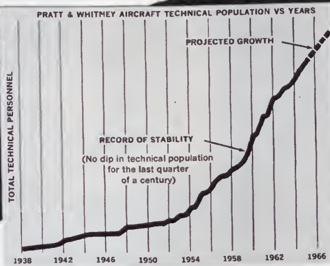
Present



In recent years, planes powered by Pra & Whitney Aircraft have gone on to se new standards of performance in much the same way as the Wasp had done in the 1920's. The 727 and DC-9 are indicative o the new family of short-to-medium range jetliners which are powered by the high successful JT8D turbofan. Examples o current military utilizations are the J58 powered Mach 3 YF-12A which recent established four world aviation records an the advanced TF30-powered F-111 variable geometry fighter aircraft.

Your

and ~~the~~ Future



Take a look at the above chart; then a good long look at Pratt & Whitney Aircraft—where technical careers offer exciting growth, continuing challenge, and lasting stability—where engineers and scientists are recognized as the major reason for the Company's continued success.

Engineers and scientists at Pratt & Whitney Aircraft are today exploring the ever-broadening avenues of energy conversion for every environment . . . all opening up new avenues of exploration in every field of aerospace, marine and industrial power application. The technical staff working on these programs, backed by Management's determination to provide the best and most advanced facilities and scientific apparatus, has already given the Company a firm foothold in the current land, sea, air and space programs so vital to our country's future. The list of achievements amassed by our technical staff is a veritable list of firsts in the development of compact power plants; dating back to the first Wasp engine which lifted the United States to a position of world leadership in aviation. These engineering and scientific achievements have enabled the Company to obtain its current position of leadership in fields such as gas turbines, liquid hydrogen technology and fuel cells.

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For further information concerning a career with Pratt & Whitney Aircraft, consult your college placement officer—or write Mr. William L. Stoner, Engineering Department, Pratt & Whitney Aircraft, East Hartford, Connecticut 06108.

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MECH MISS

"The Sweetheart of Theta Tau"

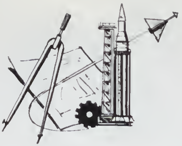
MISS ELLEN JO WEBER

This month's pretty Mech Miss is brown-eyed Ellen Jo Weber, a sophomore majoring in Sociology.

This 5' 3½" coed was born in Bridgeport, Conn. but lived most of her 19 years in Chicago where she developed an avid interest in sailing.

Here at G.W., Ellen is an active member of Phi Sigma Sigma sorority, the Chairman of the Homecoming Committee, a member of Tassels, and President of her floor of "Superdorm."

TECH NEWS



by Tom Dillon

COMPUTER ASSISTED INSTRUCTION

In IBM's experimental system, a teacher's instructions, questions and guidance are stored in the computer and presented to students on typewriter consoles or other student station equipment. Since the student's response — made on the typewriter -- can be analyzed by the computer, presentation of subsequent course material can be tailored to the needs of each student.

At present, each student station consists of a typewriter console, through which the student receives directions from the system. The student's response on the typewriter can be many words in length. The computer analyzes the student's reply, and, according to the plan laid out by the teacher, responds with clues, questions, remedial study matter, drills or the next assignment. The computer also can record response times, errors and other data on the student's performance. Thus, an extensive analysis of both student performance and the adequacy of the course is possible — with the opportunity of improving each.

The extensive record-keeping capability of the computer system will also permit valuable research on teaching techniques and the learning process itself. Thus, apart from its usefulness as an instructional tool, computer assisted instruction should lead to better understanding of the educational process.

With the present experimental system, a teacher can simply type his course material, along with a few special symbols, at one of the typewriter stations. The computer then generates its own detailed instructions for handling each section of the course material.

An experimental course in elementary statistics is similar to a sophisticated version of the "scrambled textbook" -- Programmed Textbook. However, in this course, the student constructs his answer rather than making a multiple-choice answer. The computer compares the constructed answer with anticipated responses stored in the machine to determine what action to take next. By using the computer in this way, a student can be branched to different remedial materials, depending upon his answer. In addition, his previous responses may be used to determine what material will be presented next.

In solving numerical problems in the statistics course, students took advantage of the high-speed computational abilities of the computer directly through the typewriter student station. They used the typewriter station to perform addition, subtraction, multiplication, division, squares and square roots. Although there was no limit to the number of trials a student could make, he could ask for the correct answer if he wished. The computer recorded his mistakes and later repeated the exercises which were not answered correctly. If the student missed too many exercises, the entire lesson was presented again later.

C	WHAT IS 2^3?
S	-1
C	OO NOT SUBTRACT. $2^3 \neq (2-3)$ OR $(3-2)$. TRY 2^3 AGAIN.
S	2.3
C	2^3 IS NOT ANOTHER WAY OF WRITING 2.3. ^{3} IS AN EXPONENT. TRY 2^3 AGAIN.
S	5
C	DO NOT AOO THE BASE AND THE EXPONENT. $2^3 \neq 2+3$. TRY 2^3 AGAIN.
S	6
C	DO NOT MULTIPLY THE BASE ANO THE EXPONENT. $2^3 \neq 2 \cdot 3$. TRY 2^3 AGAIN.
S	8
C	CORRECT

Typewritten record of a lesson in mathematics, using computer assisted instruction. This sample lesson shows how specific hints and guidance can be given to a student in response to an incorrect answer. The letters in the left-hand column indicate: computer typeout (C) and student's answer (S).

INDEX TO ADVERTISERS

CAMPUS NEWS

THETA TAU

HAMMER AND TONG

(FOR MEN ONLY)

by Doug Lowe
Scribe
Gamma Beta Chapter

You are studying to be an engineer, right? Sometimes it becomes pretty hard to keep your mind on all the work you know you should be doing, but with characteristic desire and determination you keep at it, plugging away far into the night. Somewhere, sometime, someone has told you that this is the way to become a successful engineer. That someone was right, undoubtedly, but not completely. Keep reading.

Certainly, technical competence is a must. You will not last long if your bridges collapse or your circuits burn out or your bottlers break all the bottles. However, competence is only a necessary condition and not a sufficient one for success, so don't put all your eggs in one basket. You might wake up at graduation to find that you are an educated, but unhatched, egg-head. When you do finally crack the academic shell, you will have a lot of growing to do in order to reach the levels of maturity demanded on the outside.

Instead of taking this stop-and-grow approach it might be more beneficial to bring your life to the campus so that your growth as a person will parallel your progress as a student engineer. That is what Theta Tau is all about. It is called a national professional engineering fraternity, meaning that it is a group of students in engineering curricula who have found that professional, personal, and social development are inseparable -- and impossible alone.

Suppose for a moment that you do try to make it on your own. It is quite difficult to make strong friendships with people whom you see only in the classroom or talk to only in the halls. If you are lucky enough to find one good friend, maybe he will help you over the rough spots in college. Maybe he will provide tutoring assistance if you need it. Maybe he will arrange a banquet and ball for you if you want to be fancy or a picnic if you would prefer that. Maybe he will invite professionals in to tell you about your future as an engineer or to discuss new advances in your field. Maybe when you are tired of studying and need some exercise he will play football, basketball, or baseball with you.

Maybe you are expecting a great deal from one person.

Theta Tau does these things. Married, single, young, older, part-time, full-time -- all varieties of students are represented in Theta Tau. Their purpose is to get the greatest benefit out of their years at college by using the experience of many previous undergraduates to guide them along the way. If you are a first semester freshman, you will have to make it on your own until next semester. If you are somewhere between that first semester and your last semester as an undergraduate, it is about time that you started to do some thinking. There will be another group of students joining Theta Tau in the Spring. Maybe you can be one of them.

There is a Theta Tau mailbox in the D-H House if you would like to contact the present members.

ASCE

by John Scott

The ASCE student chapter at G.W.U. is an organization of students of Civil Engineering and its associated branches. Meetings are held the first Wednesday of each month at posted times. A speaker or film at every meeting gives the members insight into the areas of engineering not usually covered in the classroom.

Officers

President . . . . Jim Webster
Vice President . . . . Eric Mendelsonn
Treasurer . . . . Wayne Stanton
Secretary . . . . Allie Ash
Chief of Protocol . . . . John Scott

CAMPUS NEWS

IEEE

by Joe Proctor

The George Washington University student branch of the I.E.E.E. held its first meeting of the academic year on Wednesday evening, October 6th. This was a joint introductory meeting also attended by members of the A.S.C.E. and A.S.M.E.

The I.E.E.E. is the Institute of Electrical and Electronics Engineers. It is the largest professional organization in the world. In addition to its many activities across the nation on a professional engineering level, the I.E.E.E. also encourages the founding and development of student branches. G.W. is fortunate in being one of the five institutions in the Washington area to have established a student chapter.

The purpose of the student chapter is to assist all students in electrical engineering and associated fields. The monthly meeting is the basic tool for helping the student. Therefore, the goal of the first meeting was to provide interested students with a sample of the activities of the engineering societies.

Mr. William P. O'Leary from the Office of Administration and Technical Services at the Goddard Space Flight Center spoke on the Status of the Manned Space Flight Program. In addition to providing general information on the purpose and function of N.A.S.A. and a very interesting demonstration of telemetry, Mr. O'Leary also presented a film of the complete operation of the Gemini V launch, including the walk in space.

On November 3rd, the three engineering societies will hold separate meetings at Tompkins Hall. The I.E.E.E. will hold its meeting in room 200, beginning at 8:30 p.m. Following a short business meeting, there will either be a presentation by an outstanding speaker or a film will be shown. As usual, a wide variety of free refreshments will be served at the end of the meeting. Subsequent meetings will be held on the first Wednesday of every month, except January, at the same time and place.

ASME

by Jim Garner

The George Washington University student section of the American Society of Mechanical Engineers held its first meeting of the school year on October 6, 1965. The three engineering professional societies joined together to listen to a talk by Mr. O'Leary of Goddard Space Flight Center on "Man's Walk in Space".

The officers for this semester are:

Norman Hess . . . . Chairman
Bruce Howard . . . . Vice-Chairman
James Garner . . . . Secretary-Treasurer

Professor Hyman is the newly appointed faculty advisor.

The November meeting will be held on November 3 at 8:00 p.m. Watch the bulletin boards for the room number.

THE TRANSDUCER AND MEASUREMENT SCIENCE

Continuation from Page 7 . . . .

The reason for this last requirement follows from two of the most important of Professor Stein's principles of measurement science:

> "The measurement instrument always affects the quantity to be measured.
> The quantity to be measured always affects the measuring instrument."

A classic example, is the use of a voltmeter to measure the voltage of a battery. If the voltmeter draws current from the battery, then the measured voltage differs from the true voltage by the quantity IR where I is current and R is the internal resistance of the battery.

Fortunately, however, once the principle above is known, it is possible to make allowances for it when a factor that Professor Stein calls the "isolation ratio" is known.

INTERACTION BETWEEN TRANSDUCERS

The isolation ratio is a measure of the amount of interaction between two transducers or a transducer and a source, a "transducer" with $I_p = I_s = O$. (See figure 2.)

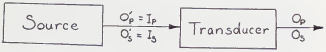


Figure 2

The isolation ratio is defined as

$$Q = A_m/(A_m + E_s). \qquad (9)$$

where A_m is the acceptance of the measuring transducer, and E_s is the emittance of the source.

The reason for this definition can be understood by looking at the simple electrical circuit shown in Figure 3.

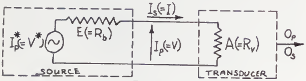


Figure 3

$$I_p^* - EI_s + AI_s \text{ or } I_p^* = I_s\,(A + E) \qquad (10)$$

Upon substituting I_p/A for I_s in this equation, we have

$$I_p^* = I_p\,(\frac{A + E}{A}) \qquad (11)$$

But by definition, equation (9), A + E)/A is just 1/Q, so we have finally

$$Q = \frac{I_p}{I_p^*} \qquad (12)$$

Equating the two expressions for Q, equations (9) and (10), we have

$$\frac{I_p}{I_p^*} = \frac{A_m}{A_m + E_s} \qquad (13)$$

Professor Stein gives this as a completely general result, but without proof. (Here we have only shown it to be true in the case of an electrical circuit.) And in his treatment, I_p is the measured value of the primary quantity, and I_p^* is the true value of the quantity measured under ideal conditions; that is, when Q = 1.

There are two such ideal conditions. The first is when the transducer takes no energy from the source, when $A_m = \infty$. The second is when the source is "ideal" and has an infinite supply of energy. Then O_p remains independent of the value of I_s; that is, $E_s = O$. Neither of these conditions is satisfied in reality, but equation (13) gives us a means of correcting the measured value I_p to obtain I_p^*, the quantity actually desired in most measurements.

A SIMPLE APPLICATION

As a simple application of the above principles, suppose that in figure 3, the source was a battery and the transducer was a voltmeter. Then the source emittance (E_s) would be the internal resistance of the battery R_b, and the transducer acceptance (A_m) would be the voltmeter resistance R_v.

The isolation ratio, therefore, would be

$$Q = \frac{R_v}{R_v + R_b}$$

Now using equation (12) the isolation ratio is also

$$Q = \frac{I_p}{I_p^*} = \frac{V}{V^*}$$

where V is the voltage read from the meter deflection (the primary output quantity, O_p), and V* is the true battery voltage. Equating the two expressions for Q and solving for V*, we have

$$V^* = V\,(1 + \frac{R_b}{R_v})$$

The relative error of measurement, then, is the term R_b/R_v which would be zero if $R_v = O$ or $R_v = \infty$.

IN CONCLUSION

Although the above example deals with a purely electrical system, the method is completely general and can be applied to any measurement system — mechanical, chemical, thermal, etc. Professor Stein, in his paper, uses an example in which a dial gage (for the measurement of displacement) is used to find the spring constant of a cantelever beam.

In this paper, we have emphasized the "interaction error" of transducer measurements. This is by no means the only error that occurs in measurements. Errors involved in the determination of the transducer transfer function are usually more troublesome. But the interaction error is the one forgotten more often than any other in the analysis of measurement system error.

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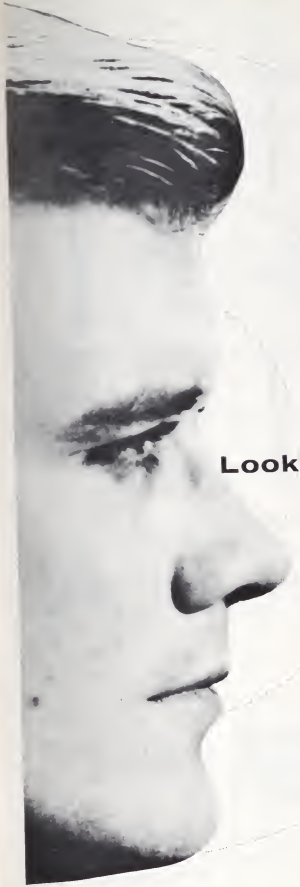
2. Louis de Pian and Robert M. Moore, "Understanding Linear Electromechanical Transducers," Electronic Products, October 1964.



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This new line of High Speed Bolts requires only half the time to fasten because there are only half the usual number of threads. This means that you can use twice as many bolts per unit area with no increase in labor costs.

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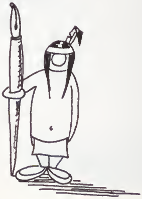

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Dale Anderson
B.A., Wittenberg University

At many companies the opportunity to work on challenging projects comes after many years of apprenticeship and a few grey hairs. Not so at Ford Motor Company where your twenties can be a stimulating period. There are opportunities to prove your worth early in your career. Dale Anderson's experience is a case in point.

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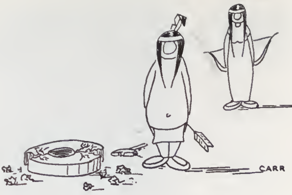
THE SHAFT



"Did you follow my advice about kissing your girl when she least expects it?" asked the sophisticated college senior of his younger fraternity brother.

"Oh, hell," said the fellow with the swollen eye, "I thought you said where."

* * *

It's hard to keep a good girl down--but fun trying.

* * *

The boss had listened in sympathetic silence as Sylvester went through the reasons why he needed, and felt he deserved, a raise. Then, with a benevolent smile, he patted the younger man on the shoulder. "Yes, Sylvester," he said kindly, "I know you can't get married on the salary I'm paying you--and someday you'll thank me for it."

* * *

She was "honeychile" in New Orleans,
The hottest of the bunch;
But on the old expense account,
She was gas, cigars and lunch.

* * *

After the lavish wedding reception, the newlyweds retired to their honeymoon suite. The groom turned down the lights and found something suitably romantic on the radio. Then he excused himself and returned in pajamas and robe. He opened a bottle of champagne and poured them each a drink, then he took his bride by the hand and tenderly led her toward the bedroom.

"Damn," she muttered, "every time I go out with a guy it ends up the same way."

* * *

A drunk staggered into the police station and confessed that he had pushed his wife out of the tenth story window.

"Did you kill her?" asked the Sgt.

"I don't think sho. Thash why I wanna be locked up."

Girls who don't repulse men's advances advance men's pulses.

* * *

A gold digger is a girl who breaks dates by going out with them.

* * *

A man-about-town we know has no trouble leaping out of bed as soon as the first ray of sunshine enters his window. His window faces west.

* * *

These days, too many beautiful women are spoiling their attractiveness by using four-letter words--like don't, and can't, and won't.

* * *

The stunning coed was stunned herself when the biology professor asked her, "What part of the human anatomy enlarges to about 10 times its normal size during periods of emotion or excitement?"

"I-I refuse to answer that question," the girl stammered, as she shyly avoided looking at her male classmates sitting nearby. One of them was called upon next and he correctly answered, "The pupil of the eye."

"Miss Smith," said the professor, "your refusal to answer my question makes 3 things evident. First, you didn't study last night's assignment. Second, you have a dirty mind. And third," concluded the professor, "I'm afraid marriage is going to be a tremendous disappointment to you."

* * *

Two well-dressed, matronly women entered the business office and approached an executive.

"Sir," said one, "we are soliciting funds for the welfare and rehabilitation of wayward women. Would you care to donate?"

"Sorry," replied the exec, "but I contribute directly."

Say it with flowers, say it with sweets,
Say it with kisses, say it with eats,
Say it with jewelry, say it with drink,
But never, oh never, say it with ink.

* * *

The moon was yellow, the lane was bright, as she turned to me that night.

And every gesture and every glance gave hint that she craved romance.

I stammered, stuttered, fumed and fumbled, and time went by - the moon was yellow and so was I.

* * *

Whoever said "Live and Learn" was a dreamer. In this day we have time to do one or the other, but not both.

* * *

I used to love my garden,
But now my love is dead,
For I found a bachelor button
In black-eyed Susan's bed.

* * *

All it really takes to separate the men from the boys is girls.

* * *

Six fraternity men came weaving out of the off-campus gin mill and started to crowd themselves into the Volkswagen for the ride back home. One of them took charge.

"Herbie," he said, "you drive. You're too drunk to sing."

* * *

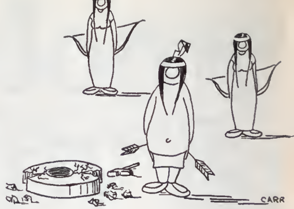
The Dean of Women at a ritzy girl's school was lecturing the freshmen on morals and behavior.

"In moments of temptation," she said, "ask yourself just one question--is an hour of pleasure worth a lifetime of shame?"

A demure young thing in the back of the room raised her hand.

"Tell me, Dean, how do you make it last an hour?"

SHAFTED AGAIN



"Hi, Charley," greeted the one, "how's your wife?"

"Compared to what?" responded the other.

* * *

The old maid rushed up to the policeman. "I've been raped, I've been attacked," she cried. "He ripped off my clothing. He smothered me with burning kisses, then he made mad, passionate love to me!"

"Calm yourself, calm yourself, madam," said the officer. "Just when did all this take place?"

"Twenty-three years ago this September," said the woman.

"Twenty-three years ago!" he exclaimed. "How do you expect me to arrest anyone for something he did twenty-three years ago?"

"Oh, I don't want you to arrest anyone, officer," said the woman. "I just like to talk about it, that's all."

* * *

We've just heard about the girl who was picked up so often that she began to grow handles.

* * *

What are you nagging me about?" complained the husband. "I was in last night by a quarter of 12."

"You were not, you liar!" cried the irate wife. "I heard you come in and the clock was striking three."

"Well, stupid," said hubby, "isn't three a quarter of 12?"

* * *

Almost as pitiable as the fellow who was tried and found wanting is the guy who wanted and was found trying.

* * *

Card playing can be expensive--but so can any game where you begin by holding hands.

* * *

Add "umph" to "try" and you get "triumph."

The biggest difference between men and boys is the cost of their toys.

* * *

An undergraduate discovered a way to cut classes at the correspondence school he's attending. He sends in empty envelopes.

* * *

A little boy prayed: "Lord, if you can't make me a better boy, don't worry about it. I'm having a real good time as it is."

* * *

Trouble with being the best man at a wedding is that you don't get a chance to prove it.

* * *

Some years ago when the G.W. football team was playing Army at D. C. Stadium, the game was hard fought and a number of penalties were called, most of them against G.W. Sitting directly back of us were four coeds, who did not take kindly to these G.W. setbacks. After one 15-yard penalty, a coed demanded, "What's it for this time?"

"Illegal use of hands," I told her.

"Wouldn't you know it?" she cried. "That's G.W. for you everytime!"

* * *

Life is what happens to you while you're busy making other plans.

* * *

Beau: "So you say your big sister sent you down to entertain me until she comes down?"

12-year old: "Yes, shall we turn on the radio and shake it up, or do you want to neck?"

* * *

Rear window sticker: "If you're driving, be careful--I'm walking. If you're walking, be even more careful--my wife's driving."

* * *

"My father can whip your father."
"Big deal. So can my mother."

Census taker: "When did your husband die?"

Widow: "Six years ago."

Census taker: "But you have a child 4 years old and one 2."

Widow: "Look, it was him that died not me!"

* * *

He: "Are you unattached?"

She: "No, just put together loosely."

* * *

Two young sisters had been given parts in a Christmas play at school. At dinner that night they got into an argument as to who had the most important role. Jody, aged 11, was very superior.

"Why, of course mine's the biggest part," she told five-year-old Lucy. "Anybody'll tell you it's much harder to be a virgin than an angel."

* * *

Cop: "What're you doing on the streets at this hour?"

Drunk: "I'm going to a lecture."

Cop: "You won't find any lectures around here at 3 a.m."

Drunk: "Wanna bet? Follow me home!"

* * *

Though it's subject to a lot of abuse, we should remember that the automobile has proven to be a great moral force in America. It stopped a lot of horse stealing.

* * *

Luke: Gosh, but I'd like to make your dreams come true.

Lulu: I'll slap your face if you try it.

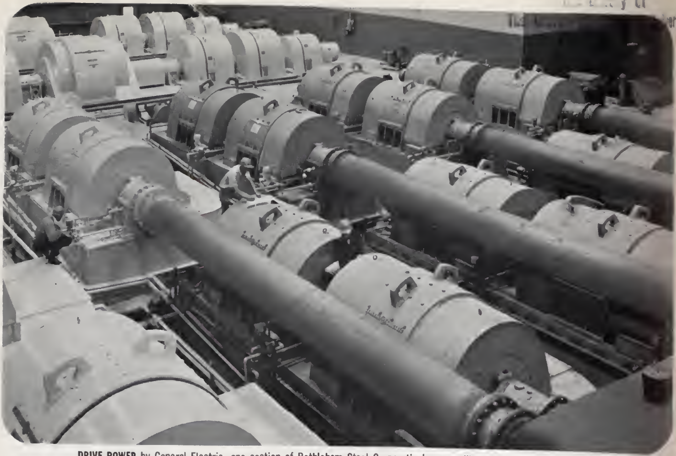
* * *

Physics prof.: "If in going down this incline, I gain four feet per second, what will be the condition after 25 seconds?"

Smart soph.: "You'll be a centipede."

* * *

A note to the wise: It's better to be hot and bothered than satisfied and worried.



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INDUSTRY CONTROL engineer Bob Vaughn, Virginia Polytechnic Inst., worked on drives, control and the new SCR armature regulator, from design through installation.

PRINTED CIRCUIT PROCESS heart of automatic control, was checked by Glenn Keller, Lehigh U., on the Manufacturing Program at Specialty Control Department.

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